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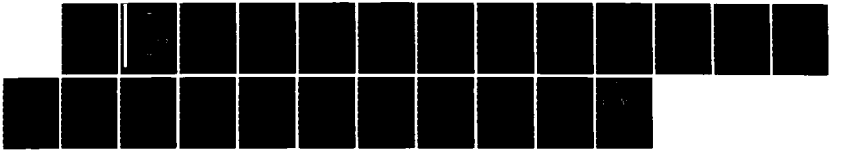

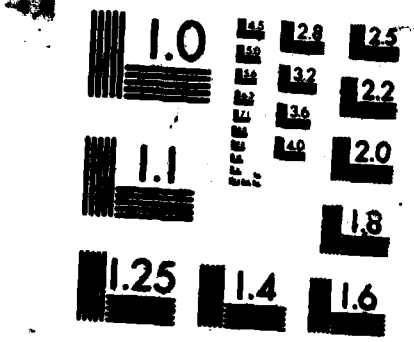

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AFFSE REPORT 2/85

EVALUATION OF WATER STERILIZING TABLETS (U)

G. F. THOMSON
K. W. JAMES
G. E. DRIVER
A. T. HANCOCK

Approved for Public Release

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SUMMARY

Water sterilizing tablets were evaluated for efficiency of kill of micro-organisms, effect of inhibitors and palatability. The effect of long term use is discussed. The water sterilizing tablet recommended for disinfection of personal drinking water, on the basis of these trials is the *Potable Aqua* tablet. The *Afsas* is not recommended because of its need for a quiescent period. The *Puritabs* is not recommended because of its inability to achieve the required 99.9% kill in heavily contaminated water, especially at alkaline pH values. Fortified beverage powders, which are effective detasting agents, will inactivate the disinfecting agent if added before completion of the recommended contact period.

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16. Abstract

Water sterilizing tablets were evaluated for efficiency of kill of micro-organisms, effect of inhibitors and palatability. The effect of long term use is discussed. The water sterilizing tablet recommended for disinfection of personal drinking water, on the basis of these trials is the *Potable Aqua* tablet. The *Afses* is not recommended because of its need for a quiescent period. The *Puritabs* is not recommended because of its inability to achieve the required 99.9% kill in heavily contaminated water, especially at alkaline pH values. Fortified beverage powders, which are effective detasting agents, will inactivate the disinfecting agent if added before completion of the recommended contact period.

CONTENTS

INTRODUCTION

This report deals with trials to test the efficiency of the water sterilizing tablets:— *Afses, Puritabs,* and *Potable Aqua.*

The investigation was initiated in response to uncertainty concerning the comparative efficiency of chlorine (*Puritabs*) versus iodine (*Afses, Potable Aqua*) disinfection, and the safety of long term ingestion of large doses of iodine (Rogers *et al*, 1977).

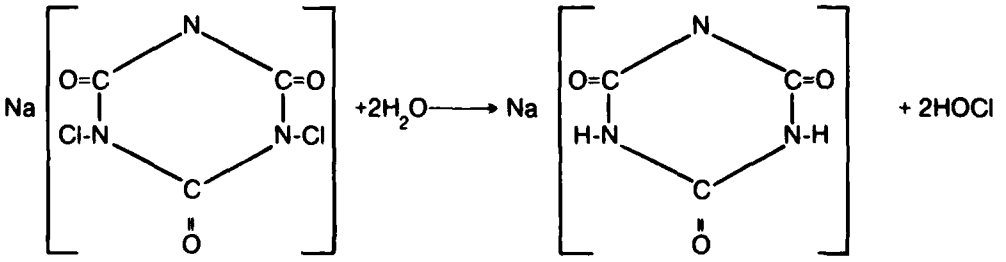
Water sterilizing tablets are used to ensure a potable supply of water:— they must be capable of destroying micro-organisms under all operational conditions. Contaminated water is a major source of bacillary dysentery. This infection is a perennial problem in military operations. For example, more men died of diarrhoeal disease during the U.S. Civil War than were killed in battle. As a seriously incapacitating disease tending to occur in epidemic form, it was a problem in World War I when, for instance, it was a significant element in the outcome of the battle of Gallipoli; during World War II especially in the South Pacific and Mediterranean areas, and subsequently in situations such as the landing of American troops in Lebanon in the late 1950's (Burrows, 1963). Amoebic dysentery was also a problem in Vietnam where it affected thousands of troops (Johnson, 1977).

Each of the sterilizing tablets depend on their ingredients reacting in water to produce their active agent. In the *Afses* tablet this agent is free iodine (8 ppm) formed from potassium iodide, potassium permanganate and potassium iodate (Heuston, 1973).

$$5KI + KIO_3 + 6H^+ \longrightarrow 3I_2 + 3H_2O + 6K^+$$

The equilibrium constant of this reaction is influenced by concentration, consequently the maximum liberation of iodine can be obtained only when the dissolving material is allowed a quiescent period, that is to form a "pool" of concentrated solution about the tablet (Rogers *et al*, 1977).

Puritabs contain sodium dichloroisocyanurate which dissociates in water to give sodium cyanurate and hypochlorous acid (10 ppm) the active agent.



Sodium dichloroiso-cyanurate

Sodium cyanurate

Hypochlorous acid

The *Potable Aqua* tablets release iodine (8 ppm) from tetraglycine hydroperiodide [$(NH_2\text{-}CH_2COOH)_4.HI..1.25I_2$] by dissociation in water.

The *Potable Aqua* were procured in two forms. Firstly in glass bottles as supplied to the United States Military and secondly in laminate blister packs as supplied on tender to the Malaysian Military.

The hypohalous acids formed by the sterilizing tablets in water ionize by the following general reaction:

$$HOX \rightleftharpoons H^+ + OX^-.$$

The influence of pH on this reaction differs greatly between hypochlorous acid (HOCl-*Puritabs*) and hypoiodous acid (HIO-*Afses, Potable Aqua*). The effect of pH on the proportion of iodine (I_2) and HIO present can be seen in Table 1 (Black *et al*, 1970). At low pH values most of the residual is in the form of elemental iodine, while at high pH values most is present as HIO. Chang (1958) has found both forms of iodine to be effective disinfectants. This is not the case with chlorine (Table 2). Chang and Morris (1953) and Keirn and Putnam (1968) have presented strong evidence that the hypochlorite ion (OCl^-), which is dominant at alkaline pH is ineffective as a disinfecting agent.

TABLE 1

Percentage of I_2 residual of 0.5 ppm present.

pH	I_2	Hypoiodous acid HIO	Hypoiodite ion IO^-
5	99	1	0
6	90	10	0
7	52	48	0
8	12	88	0.005

(Source Black *et al*, 1970)

TABLE 2

Percentage of free available chlorine.

pH	Molecular chlorine	Hypochlorous acid	Hypochlorite ion
4	0.5	99.5	0
5	0	99.5	0.5
6	0	96.5	3.5
7	0	72.5	27.5
8	0	21.5	78.5
9	0	1.0	99.0

(Source Black *et al*, 1970)

Water sterilizing tablets are used by adding one tablet to 1L of water. All manufacturers of the tablets under consideration give directions to increase the dosage to two tablets per litre if the water is considered very dirty, but no criterion is given for this assessment.

The tablet chosen must be acceptable to the user, easy to use and palatable.

Iodine is an essential element which is required for the biosynthesis of thyroid hormone. Although iodine requirements have been determined by metabolic studies there is very wide individual variation. Currently, between 100 and 200 µg are believed to be adequate daily intakes but this is dependent on factors such as subject age, sex, urinary clearance factors and the content of goitrogens elsewhere in the diet (F.D.A 1979). The recommended Australian daily dietary intake for adult males is 150 µg (Commonwealth Department of Health, 1983)

Iodine biochemistry is not well understood and there are conflicting reports about its toxicity. Chronic toxicological studies have shown that in excess of 40mg of iodine administered daily over a period of months to years may alter thyroid function which ultimately results in iodism whereas acute doses of 4g of iodine administered daily over 4 months produced no symptoms of hyperthyroidism or toxicity. Rarely, angioderma, serum sickness and haemorrhagic skin lesions occur in sensitive individuals (F.D.A., 1979).

Raper (1981) has suggested a conservative threshold of 0.2 g/day for the toxic manifestation of iodism. The occasional intake of water containing up to 10 ppm iodine would therefore be without toxicological significance. Raper believes that a more reasonable threshold for adult males is in fact 1 g/day.

Chlorine is commonly used to purify domestic water supplies; 0.2 to 10 mg/L residual free chlorine is sufficient to kill water-borne organisms (Johnson, 1977); but 200 mg/L total chlorine as Cl^- is the recommended "highest desirable level" and 600 mg/L is the "maximum permissable level" (W.H.O., 1978). Both these levels are far in excess of the level released by *Puritabs*, which therefore are unlikely to endanger human subjects. However, the practice of chlorination of domestic water supplies is coming under increasing scrutiny due to the reported formation of trihalomethane compounds (Laboratory of the Government Chemist, 1981). Trihalomethane compounds in trace amounts are under investigation as causes for rectal, bladder, and colonic cancer (Hogan *et al* 1979; Carlo & Mettlin, 1980; Kimpton, 1981).

The formation of trichloromethane compounds can be caused by the reaction of humic substances with ethanol and chlorination products in the water (Kimpton, 1981); Coleman *et al* (1984) generated halogenated derivatives of humic acids and associated substances in the absence of UV light within 90 hours under typical chlorination conditions. Therefore, it is likely that such compounds would form in a service canteen through disinfection of natural waters with sterilizing tablets.

MATERIALS AND METHODS

The trial protocols were based on the following criteria.

a. Efficiency of kill of micro-organisms.

b. Effect of inhibitors.

c. Palatability.

d. Long term use without harmful side effects.

TREATMENTS OF TEST SOLUTIONS WITH STERILIZING TABLETS

Afses were obtained from four to six year old stocks held at the Armed Forces Food Science Establishment (AFFSE). The tablets were the most recently manufactured by Sigma (Pharmaceuticals) Pty. Ltd., Australia. The tablets were dissolved according to the manufacturer's directions. One tablet was added to 1L of water, allowed a quiescent period of 5 minutes, and then shaken. An additional 20 minutes was allowed as directed.

For the microbiological examinations the *Afses* tablets were evaluated after two methods of treatment. Firstly, the tablet was stirred immediately and continuously after addition to the water, avoiding quiescence. Secondly, the tablet was treated according to the instructions which stipulate a 5 minute quiescent period.

Puritabs were also obtained from stocks less than one year oid held at AFFSE. These tablets are manufactured by the Schering Corporation, U.S.A. One tablet was added to 1L of water and allowed a contact time of ten minutes as described in the directions. The tablets are effervescent and no direction is given to stir the treated water.

Potable Aqua tablets were freshly supplied by the Wisconsin Pharmacal Co., U.S.A. One tablet was added to 1L of water. A period of five minutes was allowed before the vessel was shaken. A further contact time of twenty minutes was then allowed as directed. The manufacturer's directions for the *Potable Aqua* tablets in laminate necessitated an initial period of three minutes before agitation, followed by a further ten minutes contact. These tablets were evaluated after two contact periods; after 13 mins as described by the instructions and after 25 mins as for *Afses*.

MICROBIAL METHODS

The efficiency of kill of each tablet was estimated using water containing *Staphylococcus aureus* N.C.T.C. 6571, *Pseudomonas aeruginosa* N.C.T.C. 6749 and *Escherichia coli* N.C.T.C. 8196. The inoculated water was prepared by addition of 0.5 mL of an overnight culture of each organism in nutrient broth medium, per litre of deionised water. The final concentration of bacteria was approximately 10^6 mL^{-1}.

The Standard Plate Count (S.P.C.) method as described in AS 1095.1 (1971) was used to determine the total number of viable bacteria present. Coliforms were enumerated according to the Most Probable Number (M.P.N.) technique as described in AS 1095 Part 3.1 (1973). The active agent of each tablet was neutralised after its specified contact period, with 5% (w/v) sodium thio-sulphate solution (W.H.O. 1978).

CHEMICAL METHODS

Iodine The free iodine (I_2) was determined by titration against 0.1 N sodium thiosulphate as described by Vogel (1955).

Iodide (I^-) was determined using the method described in the specification (Logistic Command Interim Specification, 1975) using an excess of sulphurous acid and back titrating with potassium iodate.

Chlorine Free Chlorine (Cl_2) was determined using the o-tolidine spectrophotometric method as described by Rand, Greenberg, and Taras (1976).

Potassium permanganate Potassium permanganate was measured using atomic absorption spectroscopy according to the method in the specification (L.C.I.S, 1975).

Ascorbic Acid (Vitamin C) Ascorbic acid was determined by the 2,6 dichlorophenolindophenol titration method as described in A.O.A.C. (1975).

INHIBITOR TESTING METHODS

The effect of a naturally contaminated stream water on the levels of active agent and efficiency of kill of each of the tablets was measured.

A simulated contaminated water (S.C.W. — Appendix A) was developed so that the sterilizing tablets could be evaluated under reproducible conditions which simulated those found in natural waters. This mixture was prepared in two strengths termed S.C.W. and double strength simulated contaminated water (D.S.S.C.W.).

Trials were conducted on the *Afses* and *Potable Aqua* tablets using Army issue water canteens. The tablets were examined using tap water, S.C.W. and D.S.S.C.W. at pH values 6, 7 and 8, and ambient temperatures. The organisms were prepared as described earlier and 925 mL of the test water was added to the canteens, filling to a level just below the base of the neck to allow some degree of agitation.

This inoculum was treated by four separate regimes:

(a)	Walk 5 min., shake, walk 20 min.	(W5SW20)
(b)	Shake immediatley, walk 25 min.	(SW25)
(c)	Walk 25 min.	(W25)
(d)	Let canteen stand 5 min., shake, walk 20 min.	(ST5SW20)

Canteens were issued 2 per person to be worn on the hips with each person having equivalent *Afses* and *Potable Aqua* treatments. Walkers were asked to walk at "brisk" but undefined speeds.

PALATABILITY

The palatability of various treatments of the tablets in water was evaluated on a taste panel by the Ranking Method. Parisienne essence was used to impart a colour similar to *Afses* treated water. When the number of treatments exceeded three, the values were adjusted to convert them to normally distributed values, so as to facilitate statistical analysis (Amerine, Pangborn & Roessler, 1965). Statistical analysis used Duncan's New Multiple Range Test, with tables of sigificance at the 5% and 1% level (Beyer, 1968).

RESULTS AND DISCUSSIONS

EFFICIENCY OF KILL OF MICRO-ORGANISMS

Table 3 details the results of analysis for iodine or chlorine released from the various tablets. All tablets were taken from single production batches. The standard deviation for iodine or chlorine released is indicative of within batch variation.

The mean concentration of chlorine released by *Puritabs* at 11.7 ppm compares very favourably with the manufacturers claim of 10 ppm. *Afses* released an average 7.5 ppm iodine which is slightly under the 8 ppm specified. The *Afses* tablets tested were four years old, which may account for this slightly low figure.

Table 3 also details the level of iodine released by *Afses* when they are continuously stirred. The mean of 3.5 ppm I_2 is markedly different from that obtained when a quiescent period is allowed and fails the specification (L.C.I.S., 1975).

The liberation of iodine from the *Potable Aqua* tablets is shown in Table 3 to conform to the manufacturer's claim of 8.0 ppm. There was no significant difference between the amount of iodine released when a quiescent period is allowed, compared to the immediate stirring technique.

TABLE 3

Variation of Release of Active Agent from Water Sterilizing Tablets

	Puritabs Cl_2 ppm Released		*Afses* I_2 ppm Released		*Potable Aqua* — Bottle I_2 ppm Released		*Potable Aqua* — laminate I_2 ppm Released
	10 min.	20 min.	Quiescent	Stirred	Quiescent	Stirred	Quiescent
Mean	11.2	11.7	7.5	3.5	8.1	7.7	8.0
Standard Deviation	1.6	0.7	0.7	0.4	0.3	0.5	0.3

Table 4 shows that *Afses* whether stirred immediately or allowed to stand for five minutes, are capable of effecting a 99.9% kill in inoculated deionized water. This conforms to the quality control specification (L.C.I.S., 1975) for Water Purification Tablets which sets down a bacteriological kill of not less than 99.9% within a 25 minute contact period.

Table 4 shows that in three out of four trials, *Puritabs* did not achieve a 99.9% kill of total viable bacteria within ten minutes contact time. However, the tablets are capable of achieving a 99.9% kill after twenty five minutes.

Table 4 shows that the *Potable Aqua* are capable of achieving a 99.9% kill with respect to total counts and coliforms.

TABLE 4

Total and Coliform count failure rates for inoculated water treated with *Afses*, *Puritabs*, and *Potable Aqua* tablets

TABLET	QUIESCENT TIME Mins	TOTAL CONTACT TIME Mins	FAILURE RATE S.P.C.	FAILURE RATE COLIFORM
Afses	5	25	0/3	0/3
Afses	0	25	0/2	0/2
Puritabs	10	10	3/4	1/4
Puritabs	25	25	0/3	0/3
Potable Aqua				
— Bottle	5	25	0/1	0/1
— Laminate	3	13	0/1	0/1
— Laminate	3	25	0/1	0/1

EFFECT OF INHIBITORS

Table 5 shows the effect of addition of drink powders containing ascorbic acid to tablet treated water. In all cases there was no residual Cl_2 or I_2 after the fruit drink powder was added at its recommended dosage. Ascorbic acid is a reducing agent which reacts with the iodine or chlorine effectively neutralising their sterilizing properties.

To avoid these effects, fruit drink powders containing ascorbic acid should only be used **after** the recommended contact time between the sterilizing tablet and water.

TABLE 5

Interaction of Fruit Drink Powders and Sterilizing Tablets

		CONCENTRATION			
STERILIZING TABLET	Active Agent	Active Agent Initial Conc ppm	Active Agent After Ascorbic Acid addition ppm	Ascorbic Acid add mg/100g powder	Residual Ascorbic Acid mg/ 100g powder
Puritabs	Cl_2	12	0	131	75
Afses	I_2	8.0	0	130	40
Afses	I_2	7.9	0	200	100
Potable Aqua					
— bottle	I_2	8.1	0	200	158
— laminate	I_2	8.0	0	200	154

Conversely the amount of ascorbic acid supplied in the fruit drink powders is also depleted when added to treated water (Table 5). The fruit drink powders provide approximately one third of ascorbic acid (Vitamin C) in some of the ration packs (James & Forbes-Ewan, 1981). A further 40% of ascorbic acid is provided in instant coffee, which may also be used to flavour water (James & Forbes-Ewan, 1981). The ascorbic acid content of both these forms of drink powder is depleted during storage. Therefore, there is a risk that if treated water is used with the components of old ration packs, the user could become deficient in ascorbic acid. This circumstance could be tolerated for short periods, but not for periods exceeding a month; the exact period depending on the nutritional status of the individual.

Table 6 illustrates the residual halogen concentration after treating natural water obtained from a small stream near a local caravan park compared with distilled water. This water was also tested directly by iodine release from potassium iodate and back titration with sodium thiosulphate and found to have a direct demand for oxidising agents equivalent to 1.3 mg iodine per litre of the water. The difference between the two results is explained by the variation between samples of natural water and also between individual sterilizing tablets (Table 3).

TABLE 6

Residual Halogen Concentration of Natural Water and Distilled Water treated with *Puritabs* and *Afses*

	Cl_2 mg L^{-1}	I_2 mg L^{-1}
Distilled water	12	7.1
Caravan Park water	9	5.6

BENCH TRIALS

Table 7 details the result of efficiency of kill of *Afses*, *Potable Aqua* and *Puritabs* when trialled in naturally contaminated water. The *Afses* and *Puritabs* achieved a 99.9% kill with respect to both total counts and coliforms. The *Potable Aqua* tablet, while passing the specification (L.C.I.S. 1975) for coliforms, did not achieve a 99.9% kill for the total count.

TABLE 7

Percentage Kill of Total and Coliform Counts for Naturally Contaminated Water Treated with Various Sterilizing Tablets

SYSTEM	TABLET	QUIESCENT TIME MINS	TOTAL CONTACT TIME MINS	PERCENTAGE KILL S.P.C.	COLIFORM
TOWN SUPPLY	*Afses*	5	25	99.96	> 99.99
	Puritabs	10	10	99.96	> 99.99
		25	25	99.98	> 99.99
CARAVAN PARK WATER	*Afses*	5	25	99.95	> 99.99
	Puritabs	10	10	99.90	> 99.99
		25	25	99.96	> 99.99
	Potable Aqua	5	25	99.40	> 99.99

Tables 8 and 9 detail preliminary work with S.C.W. and D.S.S.C.W. at pH 7.0 and ambient temperature. On the basis of the results obtained further trials were conducted on the tablets at 4°C and ambient temperature. The pH of the water (D.S.S.C.W.) was varied between 4 and 10. *Puritabs* were given a 25 minute contact period, as for the other tablets, and the vessels were swirled to aid dispersion. The *Potable Aqua* tablets as supplied in bottles were used in these trials (Tables 10 and 11).

TABLE 8

Total and Coliform Count Failure Rate for Inoculated **Single** Strength Simulated Contaminated Water Treated with Various Sterilizing Tablets

TABLET	QUIESCENT TIME MINUTES	TOTAL CONTACT TIME MINS	FAILURE RATE S.P.C.	COLIFORM
Afses	5	25	0/3	0/3
Afses	0	25	1/2	0/2
Puritabs	25	25	2/3	0/3
Potable Aqua — bottle	5	25	0/3	0/3
— laminate	3	13	0/2	0/2
— laminate	3	25	0/2	0/2

TABLE 9

Total and Coliform Count Failure Rates for Inoculated **Double** Strength Simulated Contaminated Water Treated with Various Sterilizing Tablets

TABLET	QUIESCENT TIME MINUTES	TOTAL CONTACT TIME MINS	FAILURE RATE S.P.C.	COLIFORM
Afses	5	25	0/4	0/4
Afses	0	25	2/4	1/3
Puritabs	25	25	4/4	1/4
Potable Aqua — bottle	5	25	1/4	0/4
— laminate	3	13	1/4	0/4
— laminate	3	25	0/4	0/4

The S.P.C. failure rates of *Puritabs* at alkaline pH values (Table 10) can be explained by the low percentage of hypochlorous acid present (Table 2).

Statistical evaluation of the failure rates was conducted using the Chi-square test with Yates' modification for small sample populations (Fig 1) (Moroney, 1965).

The greatest number of failures were observed when *Afses* tablets were continuously stirred. The second highest failure rate was recorded by *Puritabs*. *Afses* allowed a quiescent period, and *Potable Aqua* tablets were not significantly different.

TABLE 10

Bench trial S.P.C. failure rates for water sterilizing tablets evaluated at the 99.9% pass rate. D.S.S.C.W. was utilised at 4 deg. C and ambient temperature and various pH values.

Temperature	pH	*Afses* (S)	*Afses* (Q)	*Puritabs*	*Potable Aqua*
4°C	4	1/3	0/3	0/8	0/4
	6	0/3	0/3	4/7	0/3
	7	2/3	0/3	2/3	0/3
	8	2/3	1/3	3/7	0/3
	10	3/3	0/3	3/3	0/3
Ambient	4	0/4	0/4	0/8	0/3
	6	1/3	0/3	0/7	0/3
	7	3/3	0/3	1/3	0/3
	8	2/4	0/4	2/8	0/4
	10	3/3	0/3	3/3	0/3

(S) = stirred (Q) = quiescent

TABLE 11

Bench trial coliform failure rates for water sterilizing tablets evaluated at the 99.9% pass rate. D.S.S.C.W. was utilised at 4°C and ambient temperature and various pH values.

Temperature	pH	*Afses* (S)	*Afses* (Q)	*Puritabs*	*Potable Aqua*
4°C	4	0/3	0/4	0/8	0/4
	6	0/3	0/3	0/7	0/3
	7	1/3	0/3	0/3	0/3
	8	1/3	0/3	0/7	0/3
	10	2/3	0/3	0/3	0/3
Ambient	4	0/4	0/4	0/8	0/3
	6	0/3	0/3	0/7	0/3
	7	1/3	0/3	0/3	0/3
	8	1/4	0/4	2/8	0/4
	10	3/3	0/3	1/3	0/3

(S) = stirred (Q) = quiescent

(A) STANDARD PLATE COUNT

4°C

Afses(S) *Puritabs* *Afses*(Q) *P.Aqua*

AMBIENT

Afses(S) *Puritabs* *Afses*(Q) *P.Aqua*

(B) COLIFORMS

4°C

Afses(S) *Afses*(Q) *P.Aqua* *Puritabs*

AMBIENT

Afses(S) *Puritabs* *Afses*(Q) *P.Aqua*

(S) = stirred (Q) = quiescent

Fig. 1 Chi-square analysis of failure rates for bench trials in D.S.S.C.W. for all pH values. Treatments not joined by a line beneath are significantly different at (at least) the 5% level. Tablets are listed in ascending order of effectiveness.

Canteen Trials

Puritabs were excluded from the canteen trials because they were ineffective in the bench trials at alkaline pH. *Afses* and *Potable Aqua* were equally efficient bactericides under all conditions when testing with tap water and S.C.W. As discussed earlier, the level of iodine released from *Afses* is dependent upon the treatment. The levels released in these canteen trials were adequate to "sterilize" when using tap water or S.C.W. The increased challenge of D.S.S.C.W. resulted in failures amongst the *Afses* treatments (Table 12).

TABLE 12

Canteen trial failure rates (99.9% pass level) for water sterilizing tablets evaluated under four walking regimens. D.S.S.C.W. was utilized at 4°C and ambient temperature and various pH values.

			REGIMEN			
		pH	W5SW20[a]	SW25[b]	W25[c]	ST5SW20[d]
Afses	S.P.C.	6	3/4	0/4	1/4	0/4
		7	2/4	2/4	0/4	0/4
		8	3/4	4/4	3/4	1/4
	Coliforms	6	1/4	0/4	0/4	0/4
		7	1/4	0/4	0/4	0/4
		8	2/4	3/4	2/4	1/4
Potable Aqua	S.P.C.	6	0/4	0/4	0/4	0/4
		7	0/4	0/4	0/4	0/4
		8	0/4	0/4	0/4	0/4
	Coliforms	6	0/4	0/4	0/4	0/4
		7	0/4	0/4	0/4	0/4
		8	0/4	0/4	0/4	0/4

(a) Walk 5 minutes, shake, walk 20 minutes.
(b) Shake immediately, walk 25 minutes.
(c) Walk 25 minutes.
(d) Let canteen stand 5 minutes, shake, walk 20 minutes.

The results shown in Table 12 were subjected to a Chi-Square statistical analysis, with the following conclusions.

With respect to S.P.C., *Potable Aqua* tablets were highly significantly ($P < 0.001$) more efficient bactericides than *Afses* regardless of treatment. When pH treatments were combined for each single walking regimen, the *Afses*, when used according the manufacturer's instructions (ST5SW20), were not significantly different from the *Potable Aqua* tablets. Agitation either before walking ($P < 0.05$) or during the walk ($P < 0.01$) resulted in significant differences between *Afses* and *Potable Aqua*. At pH 8, *Potable Aqua* were significantly ($P < 0.001$) more efficient. There was no significant difference at the other pH values.

With respect to coliforms, *Potable Aqua* tablets were significantly ($P < 0.01$) more efficient than *Afses* when all conditions of mixing and pH were combined. When pH treatments were combined for each walking regimen there was no significant difference between walking regimens. *Potable Aqua* were significantly ($P < 0.01$) more efficent at pH 8 than *Afses* when walking regimens were combined for each pH value. There was no significant difference at the other pH values.

PALATABILITY

Water treated with *Puritabs* and *Afses* was evaluated for taste against tap water (0.2 ppm residual Cl_2) (Table 13). In treatment A, untreated tap water was considered significantly more palatable than the other treatments. Uncoloured *Puritabs* were also considered more palatable than either colour-treated *Puritabs* or *Afses*. The lack of a significant difference between colour-treated *Puritabs* and *Afses* suggests that the taste panel was influenced on this occasion by colour rather than taste.

When coloured treatments alone were evaluated (treatment B), the taste panel ranked coloured water as significantly more palatable than either *Afses* or *Puritabs* treated water. In a separate trial, tasters could not significantly recognise any difference between *Potable Aqua* and *Afses* treated water.

Fruit drink powders are supplied in ration packs to Australian troops. Treatment C investigated the effect of palatabily of *Puritabs* and *Afses* on reconstituted orange drink powder. The rank scores show no significant difference between either sterilizing tablet and the control.

TABLE 13

Taste Panel Rank Totals for Flavour of Treated Water

Water Treatment	None Tap Water	*Puritabs*	Coloured Water	*Puritabs* Coloured	*Afses* or Coloured *Afses*
A. Rank totals for water. Some coloured Parisian Essence. *Afses* not coloured. Normalised and corrected.	-9.4	90	124.8	146.6	148
B. Water and Parisian Essence to all samples			13	29	30
C. Water and Orange Drink Powder 80g/L including orange colour & ascorbic acid	—	—	20	23	23

Figures not joined by a line beneath are significantly different at the 5% level.

LONG TERM USE WITHOUT HARMFUL SIDE EFFECTS

The total iodine available in the *Afses* tablet calculated as iodide is a minimum of 22.4 mg per tablet according to specifcation (L.C.I.S., 1975). However, direct analysis has found values of the order of 34 mg/tablet as shown in Table 14. Therefore the user can be expected to ingest between 44.8 and 680 mg iodide per day depending on the demand for water and the iodide content of the tablets. The average is estimated to be 65 mg/day.

TABLE 14

Activity of *Afses* Tablets

	Old Tablets	Fresh Tablets	Standard (Specification)
Total iodine (as iodide)	32.4 mg	34.1 mg	22.4 mg

It is considered that the risk of iodism from *Afses* is acceptably low for use as a sterilizing tablet under emergency conditions. The *Potable Aqua* tablet is more acceptable than the *Afses* since it contains a maximum of 8 mg I_2 and has no iodide reserves as for the *Afses* tablet.

CONCLUSIONS

EFFICIENCY OF KILL OF MICRO-ORGANISMS

Afses and *Potable Aqua* Tablets meet the required quality control specification. *Puritabs* were not able to meet this specification in the manufacturer's recommended time of ten minutes. *Puritabs* did meet the specification when the contact time was increased to twenty five minutes. However the specification only requires testing in pure water.

EFFECT OF INHIBITORS

High levels of reducing substances are capable of lowering the efficiency of all of the water sterilizing tablets. The results of these trials show that *Potable Aqua* are the least affected. *Puritabs* are rejected due to the effect of alkaline pH values. *Afses* are not recomended due to their need for a quiescent period.

The addition of ascorbic acid in coffee or fruit drink powders will inactivate the sterilizing tablets. Therefore it must be emphasisied that fortified beverages should not be added to the treated water until thirty minutes after the addition of the sterilizing tablets.

PALATABILITY

Water after purification treatment by *Afses, Puritabs* or *Potable Aqua* tablets was found to be less palatable than tap water. No significant difference was found between water treated with the various tablets. However, *Afses* were less acceptable than *Puritabs* on a colour basis. This effect is neutralised by the use of fruit drink powders.

LONG TERM USE WITHOUT HARMFUL SIDE EFFECTS

The *Afses* carry a small risk of iodism with prolonged usage. The *Afses* are more suspect than *Potable Aqua* because of their larger reserves of iodide. This risk is slight and could be regarded as an acceptable risk. To date, no evidence has been shown of a user contracting iodism through the use of iodine based sterilizing tablets. However, there is considerable evidence of soldiers contracting water borne diseases through not using sterilizing agents on the water ingested. There is a risk of forming mutagenic substances such as trihalomethanes if sterilized water is stored for an extended period before consumption. The time period required before the formation of significant levels of trihalomethanes is currently unknown.

It cannot be stated that any of the tablets are without risk over long periods. It can be concluded that of the iodine based tablets, *Potable Aqua* would pose less of a risk than *Afses*.

RECOMMENDATION

If it could be assured that the *Afses* tablet would be used as directed, then continued use of this tablet would be recommended. In the absence of this assurance and in the light of the results of the canteen trials, continued use of *Afses* cannot be recommended. The use of *Puritabs* should be discontinued as they are ineffective, especially at alkaline pH in the presence of inhibitors. The *Potable Aqua* tablet is the recommended tablet, because it is effective under likely conditions of service use.

Further research should be considered into the formation of trihalomethanes under normal operational conditions.

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APPENDIX A

Formulation of Single Strength Simulated Contaminated Water

	S.C.W.*	D.S.S.C.W.**
COMPOUND	$g\ L^{-1}$	$g\ L^{-1}$
$Na_3\ PO_4\ 12\ H_2O$	0.0406	0.0812
NaK Tartrate	0.0202	0.0404
L — cysteine	0.0052	0.0104
Starch (soluble)	0.0005	0.0010
$(NH_4)_2\ SO_4$	0.0047	0.0094
NaCl	0.0269	0.0538

* Single strength
** Double strength

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